MISSION ASSURANCE REQUIREMENTS

FOR THE

OZONE MONITORING INSTRUMENT

INSTRUMENT ADAPTER MODULE (IAM)

FOR THE

EOS CHEMISTRY MISSION

DECEMBER 1999

GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

MISSION ASSURANCE REQUIREMENTS
FOR THE
OZONE MONITORING INSTRUMENT (OMI)
INTERFACE ADAPTER MODULE (IAM)
FOR THE
EOS CHEMISTRY MISSION

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CHANGE RECORD PAGE (1 of 1)

DOCUMENT TITLE: MISSION ASSURANCE REQUIREMENTS FOR THE OZONE
MONITORING INSTRUMENT (OMI)INTERFACE ADAPTER MODULE (IAM) FOR THE EOS
CHEMISTRY MISSION

DOCUMENT DATE: December 1999

ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Initial Release Baseline (Original)	12/99	ALL	Initial Release (Doc. Number GSFC 424-11-13-06) for OMI IAM Approved by CCR 424-11-13-003

MAR_OMI_IAM_Orig_12-99v2 doc (Was OMI_IAM_MAR_Orig_12-99v2 doc)

DOCUMENT TITLE: MISSION ASSURANCE REQUIREMENTS FOR THE OZONE
MONITORING INSTRUMENT (OMI)INTERFACE ADAPTER MODULE (IAM) FOR THE
EOS CHEMISTRY MISSION

RELEASE DATE: December 1999

LIST OF AFFECTED PAGES					
Page No.	Revision	Page No.	Revision	Page No.	Revision
Cover Page	Original	5-2	Original	13-2	Original
Title Page	Original	5-3	Original	13-3	Original
Signatures	Original	5-4	Original	13-4	Original
iii	Original	5-5	Original	13-5	Original
iv	Original	5-6	Original	13-6	Original
v	Original	5-7	Original	13-7	Original
1-1	Original	5-8	Original	13-8	Original
1-2	Original	6-1	Original	13-9	Original
1-3	Original	6-2	Original	13-10	Original
2-1	Original	6-3	Original	13-11	Original
2-2	Original	6-4	Original	13-12	Original
2-3	Original	6-5	Original	13-13	Original
2-4	Original	6-6	Original		
2-5	Original	7-1	Original		
3-1	Original	7-2	Original		
3-2	Original	7-3	Original		
3-3	Original	7-4	Original		
3-4	Original	7-5	Original		
3-5	Original	7-6	Original		
3-6	Original	8-1	Original		
3-7	Original	8-2	Original		
3-8	Original	9-1	Original		
3-9	Original	9-2	Original		
3-10	Original	9-3	Original		
3-11	Original	9-4	Original		
3-12	Original	10-1	Original		
3-13	Original	10-2	Original		
3-14	Original	10-3	Original		
3-15	Original	10-4	Original		
3-16	Original	11-1	Original		
3-17	Original	11-2	Original		
3-18	Original	11-3	Original		
3-19	Original	11-4	Original		
3-20	Original	11-5	Original		
3-21	Original	11-6	Original		
4-1	Original	12-1	Original		
4-2	Original	12-2	Original		
4-3	Original	12-3	Original		
4-4	Original	12-4	Original		
5-1	Original	13-1	Original		

EOS 420-CM-04 (4/92)

GSFC 424-11-13-06

TABLE OF CONTENTS

Sections   Page

Section 1   Overall Requirements   1-1
Section 2   Assurance Design Review Requirements   2-1
Section 3   Verification Requirements   3-1
Section 4   Electronic Packaging and Processes Requirements 4-1
Section 5   Parts Requirements   5-1
Section 6   Materials, Processes & Lubrication Requirements 6-1
Section 7   Reliability Requirements   7-1
Section 8   Quality Assurance Requirements   8-1
Section 9   Contamination Control Requirements   9-1
Section 10   Software Assurance Requirements   10-1
Section 11   Safety Requirements   11-1
Section 12   Applicable Documents   12-1
Section 13   Acronym List & Definitions   13-1

ILLUSTRATIONS

FIGURE   **PAGE**

Figure 3-1   Verification Test Report 3-6

Figure 3-2   Thermal/ Vacuum Test Profile 3-21

TABLE

3-1   EMC Requirements per Level of Assembly 3-19
6-1   Material Selection Criteria 6-4
7-1   Severity Categories 7-3

Original   v   December 1999

SECTION 1

OVERALL REQUIREMENTS

1.1   DESCRIPTION OF OVERALL REQUIREMENTS

This document defines the mission assurance requirements for the OMI Interface Adapter Module (IAM). The developer is required to plan and implement an organized Assurance and Safety Program that encompasses all flight hardware and software from program initiation through launch operations. In addition, this program shall assure the integrity and safety of the flight hardware and software components and the ground system software.

The Systems Assurance Manager shall have direct access to the developer's assurance management representative. The Assurance and Safety Program is applicable to the prime contractor and its associated contractors.

1.2   USE OF PREVIOUSLY DESIGNED, FABRICATED, OR FLOWN HARDWARE

When hardware that was designed, fabricated, or flown on a previous program, is considered to have demonstrated compliance with some or all of the requirements of this document such that certain tasks need not be repeated, the developer is required to demonstrate how the hardware complies with requirements.

1.3   SURVEILLANCE OF THE CONTRACTOR

The work activities, operations, and documentation performed by the developer are subject to evaluation, review, audit, and inspection by government-designated representatives from GSFC, the Government Inspection Agency (GIA), or an independent assurance contractor (IAC). GSFC will delegate in-plant responsibilities and authority to those agencies via a letter of delegation, or a GSFC contract with the IAC.

The developer, upon request, shall provide government assurance representatives with documents, records, and equipment required to perform their assurance and safety activities. The developer shall also provide the government assurance representative(s) with an acceptable work area within their facilities.

1.4   APPLICABLE DOCUMENTS (Section 12)

To the extent referenced herein, applicable portions of the documents listed in Section 12 form a part of this document.

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SECTION 2

ASSURANCE DESIGN REVIEW REQUIREMENTS

2.1 GENERAL REQUIREMENTS

The developer shall conduct a series of comprehensive subsystem-level design reviews that are chaired by the GSFC EOS Chemistry Project Office. The reviews shall cover all aspects of the flight and ground hardware, software, and operations for which the developer has responsibility.

2.2 GSFC SYSTEMS ASSURANCE DESIGN REVIEW REQUIREMENTS

For each specified review chaired by GSFC, the developer shall:

a. Develop and organize material for oral presentation to the GSFC review team. Copies of the presentation material shall be available in advance and at each review.

b. Support splinter review meetings resulting from the major review.

c. Produce written responses to the EOS Chemistry Project for recommendations and action items resulting from each review.

d. Summarize, as appropriate, the developer's assembly and subsystem level reviews.

2.3 GSFC SYSTEMS ASSURANCE DESIGN REVIEW PROGRAM

The GSFC EOS Chemistry Project Design Review Program (DRP), shall consist of individual, periodic reviews of the IAM subsystem. These reviews shall include discussions of flight hardware, flight software, and ground systems that interface with flight hardware.

a. The Design Review Team

The Design Review Team shall include personnel experienced in subsystem design, systems engineering and integration, testing, and all other applicable disciplines. The review chairperson, in concert with the EOS Chemistry Project Manager, shall appoint independent key technical experts as review team members. Personnel outside the Center may be invited as

members if it is felt their expertise shall enhance the design review team.

b. Design Review Plan (DRP)

    (1) The Chemistry Project Office shall develop design review Requests for Action (RFA) to be documented during the OMI IAM reviews. The DRP shall consist of the following reviews:

        (a) Preliminary Design Review (PDR)--This review occurs early in the design phase prior to manufacture of engineering hardware and the detail design of associated software. Where applicable, it should include the results of test bedding, breadboard testing, and software prototyping. Long-lead procurements shall be discussed.

        (b) Critical Design Review (CDR)--This review typically occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. It shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing.

        (c) Pre-Environmental Review (PER)--This review occurs prior to the start of environmental testing of the flight hardware. The primary purpose of this review is to establish the readiness of the flight hardware for system level test and evaluate the environmental test plans.

        (d) Pre-Shipment Review (PSR)--This review shall take place prior to shipment of the flight article for integration with the spacecraft. The PSR shall concentrate on IAM performance during testing.

c. Design Review Schedule

The design reviews will be conducted on a schedule determined by the GSFC Chemistry Project Office.

d. System Safety

The safety aspects of the IAM subsystem are a normal consideration in the design evaluations conducted by the DRP. System safety shall be an agenda item for each review listed, and as such shall serve to support the total system safety review program specified in Section 11 of this document.

2.4   THE DEVELOPER REVIEW REQUIREMENTS

The developer shall implement a program of internal peer reviews at the subsystem level. In addition, packaging issues shall be discussed on all electrical and electromechanical components in the hardware design.

The internal peer reviews shall evaluate the ability of the IAM subsystem to successfully perform its function under operating and environmental conditions during both testing and flight. The results of parts stress analyses, including the results of associated tests and analyses, shall be discussed at the internal peer reviews.

The internal peer reviews shall specifically address the following:

a. Placement, mounting, and interconnection of EEE parts on circuit boards or substrates.

b. Structural support and thermal accommodation of the boards and substrates and their interconnections in the component design.

c. Provisions for protection of the parts and ease of inspection.

Review results shall be documented and the made available for GSFC review at the developer's facility. GSFC reserves the right to attend the internal peer reviews and GSFC advance notification is required.

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SECTION 3

VERIFICATION REQUIREMENTS

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3.1   GENERAL REQUIREMENTS

An instrument performance verification program
documenting the overall verification plan,
implementation, and results is required to ensure
that the OMI IAM meets the specified mission
requirements, and to provide traceability from
mission specification requirements to launch and on-
orbit capability. The program consists of a series
of functional demonstrations, analytical
investigations, physical property measurements,
inspections and tests that simulate the environments
encountered during handling and transportation,
prelaunch, launch, and in-orbit. All protoflight
hardware shall undergo qualification to demonstrate
compliance with the verification requirements of
this section. In addition, all other hardware
(flight, follow-on, and spare) shall undergo
acceptance in accordance with the verification
requirements of this section.

The Verification Program begins with functional
testing of assemblies; it continues through
functional and environmental testing supported by
appropriate analysis, at the subassembly, component,
subsystem, instrument, and observatory levels of
assembly. The program concludes with end-to-end
testing of the entire operational system including
the payload, the Payload Operations Control Center
(POCC), and the appropriate network elements.

3.2   DOCUMENTATION REQUIREMENTS

3.2.1   Performance Verification Plan

A performance verification plan shall be prepared
defining the tasks and methods required to determine
the ability of the IAM to meet each program-level
performance requirement (structural, thermal,
optical, electrical, guidance/control, RF/telemetry,
science, mission operational, etc.) and to measure
specification compliance. Limitations in the
ability to verify any performance requirement shall
be addressed, including the addition of supplemental
tests and/or analyses that will be performed and a
risk assessment of the inability to verify a
requirement.

The performance verification plan shall address how
compliance with each specification requirement will
be verified. If verification relies on the results
of measurements and/or analyses performed at lower

(or other) levels of assembly, this dependence shall be described.

For each analysis activity, the plan shall include objectives, a description of the mathematical model, assumptions on which the models will be based, required output, criteria for assessing the acceptability of the results, the interaction with related test activity, if any, and requirements for reports. Analysis results shall take into account tolerance build-ups in the parameters being used.

The Performance Verification Plan shall also address environmental verification, stating the overall approach (listing tests and analyses) that will collectively demonstrate that the hardware and software comply with the environmental verification requirements. For each test, it shall include the level of assembly, the configuration of the item, objectives, facilities, instrumentation, safety considerations, contamination control requirements, test phases and profiles, necessary functional operations, personnel responsibilities, and requirement for procedures and reports. When appropriate, the interaction of the test and analysis activity shall be described.

3.2.2 System Performance Verification Matrix

A System Performance Verification Matrix shall be prepared as part of the Performance Verification Plan, and maintained, to show each specification requirement, the reference source (to the specific paragraph or line item), the method of compliance, applicable procedure references, results, report reference numbers, etc. This matrix shall be included in the system review data packages showing the current verification status as applicable. This Performance Verification Test Matrix shall be included with the plan referenced in Section 3.2.1.

3.2.3 Environmental Test Matrix

As an adjunct to the Performance Verification Plan, an environmental test matrix shall be prepared that summarizes all tests that will be performed at the component, subsystem, and instrument level. The purpose is to provide a ready reference to the contents of the test program in order to prevent the deletion of a portion thereof without an alternative means of accomplishing the objectives. All flight hardware, spares, and engineering units used in the qualification program (when appropriate) shall be included in the matrix. This matrix shall be

prepared in conjunction with and included in the Performance Verification Plan and shall be updated as changes occur.

3.2.4 Performance Verification Specification

A Performance Verification Specification shall be prepared that defines the specific environmental parameters that each hardware element is subjected to either by test or analysis in order to demonstrate its ability to meet the mission performance requirements.

3.2.5 Performance Verification Procedures

For each verification test activity conducted at the component, subsystem, and instrument levels, a verification procedure shall be prepared that describes the configuration of the test article, how each test activity contained in the verification plan and specification will be implemented.

Test procedures shall contain details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, pass/fail criteria, quality control checkpoints, data collection and reporting requirements. The procedures also shall address safety and contamination control provisions. These procedures are not a required deliverable item; however, they shall be available for review upon request.

3.2.6 Verification Reports

After each component, subsystem, and instrument verification activity has been completed, a report shall be completed. For each environmental test activity, the report shall contain, as a minimum, the information in the sample test report contained in Figure 3-1. For each analysis activity, the report shall describe the degree to which the objectives were accomplished, how well any mathematical models were validated by related test data, and other such significant results. The Verification Reports shall be prepared within 30 days following the activity, and shall be available upon request. In addition, as-run verification procedures and all test and analysis data shall be retained for review.

3.3   ELECTRICAL FUNCTION TEST REQUIREMENTS

The following paragraphs describe the required
electrical functional and performance tests that
verify the IAM operation before, during, and after
environmental testing. These tests along with all
other calibrations, functional/performance tests,
measurements/demonstrations, alignments (and
alignment verifications), end-to-end tests,
simulations, etc., that are part of the overall
verification program shall be described in the IAM
Performance Verification Plan.

3.3.1   Electrical Interface Tests

Before the integration of a subassembly or component
into the next higher hardware assembly, electrical
interface tests shall be performed to verify that
all interface signals are within acceptable limits
of applicable performance specifications. Prior to
mating with other hardware, electrical harnessing
shall be tested to verify proper characteristics
such as; routing of electrical signals, impedance,
isolation, and overall workmanship.

Figure 3-1

VERIFICATION TEST REPORT

Page _____ of _____

PROJECT _____

TEST ITEM _____

MANUFACTURER _____

SERIAL NUMBER _____

LEVEL OF ASSEMBLY	HARDWARE	TEST
☐ SUBASSEMBLY or ASSEMBLY	☐ ENGINEERING MODEL	☐ INITIAL TEST
☐ UNIT/COMPONENT	☐ PROTOTYPE	STARTING DATE OF INITIAL TEST
☐ SECTION	☐ PROTOFLIGHT	_____
☐ SUBSYSTEM/INSTRUMENT	☐ FLIGHT	☐ RETEST
☐ MODULE	☐ SPARE	☐ PARTIAL
☐ SPACECRAFT/PAYLOAD		☐ FULL

STRUCTURAL - MECHANICAL

☐ STRUCTURAL LOADS
  ☐ STATIC
  ☐ ACCEL.
  ☐ SINE BURST
☐ VIBRATION
  ☐ RANDOM
  ☐ SINE
☐ ACOUSTICS
☐ MECHANICAL SHOCK
  ☐ ACTUATION
  ☐ SIMULATED
☐ MECHANICAL FUNCTION
☐ MODAL SURVEY
☐ PRESSURE PROFILE
☐ MASS PROPERTIES
☐ OTHER (explain)

ELECTROMAGNETIC COMPATIBILITY

☐ CONDUCTED EMISSIONS
☐ RADIATED EMISSION
☐ CONDUCTED SUSCEPTIBILITY
☐ RADIATED SUSCEPTIBILITY
☐ MAGNETIC PROPERTIES

ELECTRICAL PERFORMANCE

☐ LPT
☐ CPT
☐ END-TO-END
  ☐ COMPATIBILITY TEST
  ☐ MISSION SIMULATIONS

THERMAL

☐ THERMAL-VACUUM
  (no. of cycles _____)
☐ THERMAL CYCLING
  (no. of cycles _____)
☐ THERMAL BALANCE
☐ TEMPERATURE-HUMIDITY
☐ LEAKAGE
☐ OTHER (explain)

OPTICAL

☐ EXPLAIN

VERIFICATION PROCEDURE NO.: _____ REV. _____ DATE _____
APPLICABLE VERIFICATION PLAN: _____
FACILITY DESCRIPTION: _____
LOCATION: _____
TEST LOG REFERENCE: _____
COMMENTS:

SIGNATURES
COGNIZANT ENGINEER FOR TEST ITEM:_____ DATE: _____

QUALITY ASSURANCE REPRESENTATIVE: _____ DATE: _____
  (if required)

VERIFICATION TEST REPORT (Continued)   Page_____of_____

DATE ADD TIME FOR THERMAL & TEMPERATURE TESTS	NOTE BEGINNING AND END OF ACTUAL ACTIVITY, DEVIATIONS FROM THE PLANNED PROCEDURE, AND DISCREPANCIES IN TEST TIMES PERFORMANCE. STATE IF THERE WERE NO DEVIATIONS OR DISCREPANCIES	MALFUNCTION REPORT NUMBER AND DATE AS APPLICABLE

The activities covered by these reports include tests and measurements performed for the purpose of verifying the flightworthiness of hardware at the component, subsystem, and payload levels of assembly. These reports shall also be provided for such other activities as the project may designate.

These reports shall be completed and transmitted to the GSFC Technical Officer or Contracting Officer (as appropriate) within 30 days after completion of an activity. Legible, reproducible, handwritten completed forms are acceptable

Material felt necessary to clarify this report may be attached. However, in general, test logs and data should be retained by those responsible for the test item unless they are specifically requested.

The forms shall be signed by the quality assurance representative and the person responsible for the test or his designated representative; the signatures represent concurrence that the data is as accurate as possible given the constraints of time imposed by quick-response reporting.

This report does not replace the need for maintaining complete logs, records, etc.; it is intended to document the implementation of the verification program and to provide a minimum amount of information as to the performance of the test item.

3.3.2 Comprehensive Performance Tests

An appropriate comprehensive performance test (CPT) shall be conducted at the Component and Subsystem levels. When environmental testing is performed at a given level of assembly, additional comprehensive performance tests shall be conducted during the hot and cold extremes of the temperature or thermal-vacuum test. CPTs shall also be performed at the conclusion of the environmental test sequence, as well as at other times prescribed in the Verification Plan, specification, and procedures.

The comprehensive performance test shall be a detailed demonstration that the hardware and software meet their performance requirements within allowable tolerances. The test shall demonstrate operation of all redundant circuitry and satisfactory performance in all operational modes. The initial CPT shall serve as a baseline against which the results of all later CPTs can be readily compared.

At the subsystem level, the comprehensive performance test shall demonstrate that, with the application of known stimuli, the IAM will produce the expected responses. At lower levels of assembly, the test shall demonstrate that, when provided with appropriate inputs, internal performance is satisfactory and outputs are within acceptable limits.

3.3.3 Limited Performance Tests

Limited performance tests (LPT) shall be performed at the component and subsystem levels before, during, and after environmental tests, as appropriate, in order to demonstrate that functional capability of the IAM has not been degraded by the tests. The limited tests are also used in cases where comprehensive performance testing is not warranted. In those cases, the LPT's shall become the baseline tests for performance degradation trending. LPTs shall demonstrate that the performance of selected hardware and software functions is within acceptable limits. Specific times when LPTs will be performed shall be prescribed in the verification specification.

3.3.4 Aliveness Test

An aliveness test shall be performed to verify that the IAM and its major components are functioning, and that changes or degradation have not occurred as a result of environmental exposure, handling, transportation or faulty installation. This test shall be performed after major environmental tests, handling and transportation of the instrument, and shall be significantly shorter in duration than a CPT or LPT. Specific times when aliveness tests will be performed shall be prescribed in the verification specification. The IAM is to be subjected to an aliveness test at the instrument and observatory level.

3.3.5 Performance Operating Time and Failure-Free Performance Testing

At the conclusion of the performance verification program, the IAM shall have demonstrated failure-free performance testing for at least the last 100 hours of operation. The demonstration may include operating time at the subsystem level of assembly when instrument testing provides insufficient test time to accumulate the trouble-free-operation, or when integration is accomplished with the instrument. Failure-free operation during the thermal-vacuum test exposure is included as part of the demonstration of the trouble-free operation being logged at the hot-dwell and cold-dwell temperatures. Major hardware changes during or after the verification program shall invalidate previous demonstration.

3.3.6 Testing of Limited-Life Electrical Elements

A life test program shall be considered for electrical elements that have limited lifetimes as identified in the Limited-Life Items (section 7.4). The verification plan shall address the life test program, identifying the electrical elements that require such testing, describing the test hardware that will be used, and the test methods that will be employed.

3.4   STRUCTURAL AND MECHANICAL REQUIREMENTS

The developer shall demonstrate compliance with structural and mechanical requirements through a series of interdependent test and analysis activities. The demonstrations shall verify design and specified factors of safety, ensure launch vehicle interface compatibility, acceptable workmanship, and material integrity. In addition, certain activities needed to satisfy the safety requirements may best be accomplished in conjunction with these demonstrations.

When planning the tests and analyses, the developer shall consider all expected environments including those of structural loads, vibroacoustics, mechanical shock, and pressure profiles. Mass properties and mechanical functioning shall also be verified.

The program outlined below assumes that the design of the IAM is sufficiently modularized to permit realistic environmental exposures at the component level. It is emphasized that each component of the IAM (structure, power, command and data handling, etc.) must be verified for each of the requirements identified below. In some cases, it may be desirable to satisfy the requirements by test at the component or subsystem level in lieu of testing at the subassembly level.

It is the developer's responsibility to document a meaningful set of activities that best demonstrate compliance with the requirements.

3.4.1   Structural Loads

3.4.1.1 <u>Design Verification</u>

Verification for the structural loads environment shall be accomplished by a combination of test and analysis. A modal survey shall be performed at the subassembly level to verify that the analytic model adequately represents the hardware's dynamic characteristics. The test-verified model shall then be used to predict the maximum expected load for each potentially critical loading condition, including handling and transportation, vibroacoustic effects during lift-off. The maximum loads resulting from the analysis define the limit loads.

The proposed use of materials that are susceptible to brittle fracture ($K_{Ic}/F_{ty}<0.33$ in.$^{1/2}$) or stress corrosion cracking (non-Table I per MSFC-SPEC-522) require approval of the project Materials Assurance Engineer (MAE). Definition of and strict adherence to appropriate additional procedures to prevent problems are also required.

It is emphasized that all structural elements shall be in compliance with applicable safety requirements discussed in Section 11 of this document.

3.4.1.2 <u>Flight Acceptance</u>

Verifying the hardware for adequate design strength can be met by applying a set of loads equal to 1.25 times the limit loads after which the hardware must be capable of meeting its performance criteria. In order to comply with safety and performance criteria, the strength verification test must be accompanied by a stress analysis that predicts that no ultimate failure will occur at loads equal to 1.40 times limit.

If appropriate development tests are performed to verify accuracy of the stress model, and stringent quality control procedures are invoked to ensure conformance of the structure to the design, then strength verification may be accomplished without test by a stress analysis that demonstrates that the hardware has positive margins on yield at loads equal to 2.0 times the limit load, and positive margin on ultimate at loads equal to 2.6 times the limit load.

Structural design loads testing is not required for flight structure that has been previously qualified for the current mission as part of a valid protoflight test.

3.4.2   Vibroacoustics

3.4.2.1 <u>Design Verification</u>

To satisfy the vibroacoustic requirements, a design verification test program shall be developed which is based on an assessment of the expected mission environments. An acoustic test at the observatory level will be required.

For verification, the input test levels are 3 dB above the maximum expected flight environment. When

random vibration levels are determined, responses to the acoustic inputs plus the effects of vibration transmitted through the structure shall be considered. If analysis cannot demonstrate compliance for the IAM at the Observatory level test, then component random vibration level tests shall be conducted for design validation and to demonstrate acceptable workmanship. If performed, the minimum overall acoustic sound pressure level for any acoustic test should be 138 dB.

3.4.2.2 Flight Acceptance

For the acceptance of previously qualified hardware, testing shall be conducted at the maximum expected flight levels, or minimum workmanship levels, whichever is greater.

3.4.3 Sinusoidal Sweep Vibration Verification

3.4.3.1 Design Verification

The IAM Subsystem shall be subjected to a sine sweep vibration to verify their ability to survive the low-frequency launch environment. The test also provides a workmanship vibration test for hardware which normally does not respond significantly to the vibroacoustic environment at frequencies below 50 Hz, such as wiring harnesses and stowed appendages, but can experience significant responses from low-frequency sine transient vibration and any sustained, pogo-like sine vibration. It should be noted that sine sweep test will be performed at the observatory level.

For the sinusoidal vibration environment, the verification level is defined as the limit level times 1.25, and the test input frequency range shall be limited to the band from 5 to 50 Hz.

As a screen for design and workmanship defects, components shall be subjected to a sine sweep vibration test along each of three mutually perpendicular axes.

3.4.3.2 Flight Acceptance

Sine sweep vibration testing for the acceptance of previously qualified hardware shall be conducted at the flight limit levels using the same sweep rates as used for protoflight hardware.

3.4.4 Mechanical Shock

3.4.4.1 Design Verification

Both self-induced and externally induced shocks shall be considered in defining the mechanical shock environment. All components shall be exposed to all self-induced shocks by actuation of any shock-producing devices. Each device must be actuated a minimum of two times in order to account for the scatter associated with different actuations of the same device.

In addition, when the most severe shock is externally induced, a suitable simulation of that shock shall be applied at the component interface. When it is feasible to apply the shock with a controllable shock-generating device, the verification level shall be 1.4 times the maximum expected value at the component interface, applied once in each of the three axes. If it is not feasible to apply the shock with a controllable shock-generating device (e.g., the component is too large for the device), the test may be conducted at the subsystem level by actuating the shock-producing devices in the subsystem that produce the shocks external to the components to be tested. The shock-producing device(s) must be actuated a minimum of two times for the test.

3.4.4.2 Flight Acceptance

The need for mechanical shock tests for the acceptance of previously qualified hardware shall be considered on a case-by-case basis. Testing should be given careful consideration in accordance with mission reliability goals, shock severity, hardware susceptibility, and design changes that could affect proximity to the shock-producing device, and previous history.

3.4.5 Life Testing

A life test program shall be implemented for mechanical and electromechanical devices that move repetitively as part of their normal function and whose useful life must be determined in order to verify their adequacy for the mission. The developer shall identify such limited life items and the life testing approach (including augmenting

analysis) in the Performance Verification Plan. Trend analysis and reporting shall be as specified in Section 7.3, Analysis of Test Data, and Section 7.4, Limited Life Items.

For limited life items for which life-testing will not be performed, the rationale for eliminating the test shall be provided along with a description of the analyses that will be done to verify the validity of the rationale.

3.4.6 Pressure Profile

3.4.6.1 Design Verification

The need for a pressure profile test shall be assessed for the IAM subsystem. A verification test shall be performed if analysis does not indicate a positive margin at loads equal to twice those induced by the maximum expected pressure differential during launch. If a test is required, the limit pressure profile is determined by the predicted pressure-time profile for the nominal trajectory of the particular mission. Because pressure-induced loads vary with the square of the rate of change, the verification pressure profile is determined by multiplying the predicted pressure rate of change by a factor of 1.12 (the square root of 1.25, the required qualification factor on load).

3.4.6.2 Flight Acceptance

Pressure profile test requirements do not apply for the acceptance testing of previously qualified hardware.

3.4.7 Mass Properties

The mass properties program must include an analytic assessment of the IAM Subsystem's ability to comply with the mission requirements, including constraints imposed by the launch vehicle, supplemented as necessary by measurement. As a minimum, the IAM weight, mass, and center of gravity, must be measured and the results documentented. During the instrument development, it is required that this data be reported in the monthly reports and discussed at quarterly and design reviews.

3.5   ELECTROMAGNETIC COMPATIBILITY (EMC) REQUIREMENTS

It is required that the electromagnetic characteristics of hardware be such that:

a. The IAM shall not generate electromagnetic interference that could adversely affect its own components, other instruments, the spacecraft, or the safety and operation of the launch vehicle, or the launch site.

b. The IAM shall not be susceptible to emissions that could adversely affect its safety and performance. This applies whether the emissions are self-generated or derive from other sources, or whether they are intentional or unintentional.

3.5.1   Specific Requirements

The developer shall demonstrate compliance with the requirements by conducting an appropriate combination of EMC tests at the component and IAM Subsystem levels of assembly.

At the component and subsystem levels, the developer shall perform the various tests in Table 3-1. It should be noted at the observatory level, the OMI Instrument including the IAM will be subjected to specific EMC testing also referenced in Table 3-1. The design and workmanship of the IAM shall be able to withstand all the environmental tests at the observatory level.

The tests shall be performed against fixed limits as given in the General Instruments Requirements Document (GIRD). Other mission-specific requirements may be found in launch vehicle and launch site requirements documents.

3.5.2   Flight Acceptance

The EMC verification test program shall be imposed on all flight hardware to detect unit-to-unit variations in materials, and workmanship defects.

Table 3-1 EMC Requirements per Level of Assembly

Type	Test	Component	Subsystem	Observatory(*)
CE	DC power leads	R	R	-
CE	Power leads	R	R	-
RE	AC magnetic fields	R	R	R
RE	E-fields	R	R	R
CS	Pwr lines	R	R	-
CS	Pwr line transients	R	R	-
RS	E-field (general)	R	R	R
RS	Magnetic field Susceptibility	R	R	R
	Magnetic Properties	R	R	R

NOTE: All tests in the above table are discussed in the GEVS-SE.
CE - Conducted Emission; CS - Conducted Susceptibility.
R - Test to ensure reliable operation of hardware, and to help ensure compatibility with the ELV and launch site.
RE - Radiated Emission; RS - Radiated Susceptibility.
* - Observatory requirements apply when instrument is integrated; Test is Observatory contractor responsibility.

3.6   VACUUM, THERMAL, AND HUMIDITY REQUIREMENTS

In the vacuum, thermal, and humidity areas it must be demonstrated that:

a. The IAM shall perform satisfactorily in the vacuum and thermal environment of space.

b. The thermal design and the thermal control system shall maintain the affected hardware within the established mission thermal limits.

c. The hardware shall withstand, as necessary, the temperature and humidity conditions of transportation, storage, and ELV launch.

The developer shall demonstrate compliance by conducting a set of tests and analyses that collectively meet the requirements defined in the following paragraphs. Tests may require supporting analyses and vice versa.

3.6.1   Thermal-Vacuum

3.6.1.1 <u>Design Verification</u>

The thermal-vacuum test shall demonstrate the ability of the IAM to perform satisfactorily in functional modes representative of the mission in vacuum at the nominal mission operating temperatures, at temperatures 10 degrees C beyond the predicted mission extremes, and during temperature transitions. The test shall also demonstrate the ability of the IAM to perform satisfactorily after being exposed to the predicted nonfunctional extremes of the mission, including the 10 degrees C margin. Cold and hot turn-on's shall be demonstrated where applicable.

Prior to delivery, the IAM shall be subjected to a minimum of 8 thermal-vacuum temperature cycles, at least four of which shall be at the IAM Subsytem level. As a part of observatory testing, they will be subjected to at least 4 thermal-vacuum temperature cycles. During any thermal-vacuum cycling, the rate of temperature change shall not exceed 20 degrees C per hour, and soak times at temperature extremes shall not start until equilibrium is reached. For the IAM Subsystem-level tests, the IAM shall be subjected to a minimum of 4 thermal-vacuum temperature cycles, during which the instrument shall be soaked for a minimum of 16 hours at each temperature extreme of each cycle. The developer shall state in the Verification Plan, the proposed testing scenario for the IAM and its components. The hardware at all levels of assembly shall be operated and its performance monitored throughout the test. IAM turn-on capability shall be demonstrated at least twice during the low and high temperature extremes. The ability to function through the voltage breakdown region, if applicable, shall be demonstrated. Figure 3-2 presents the thermal-vacuum profile.

Figure 3-2
Thermal/Vacuum Test Profile
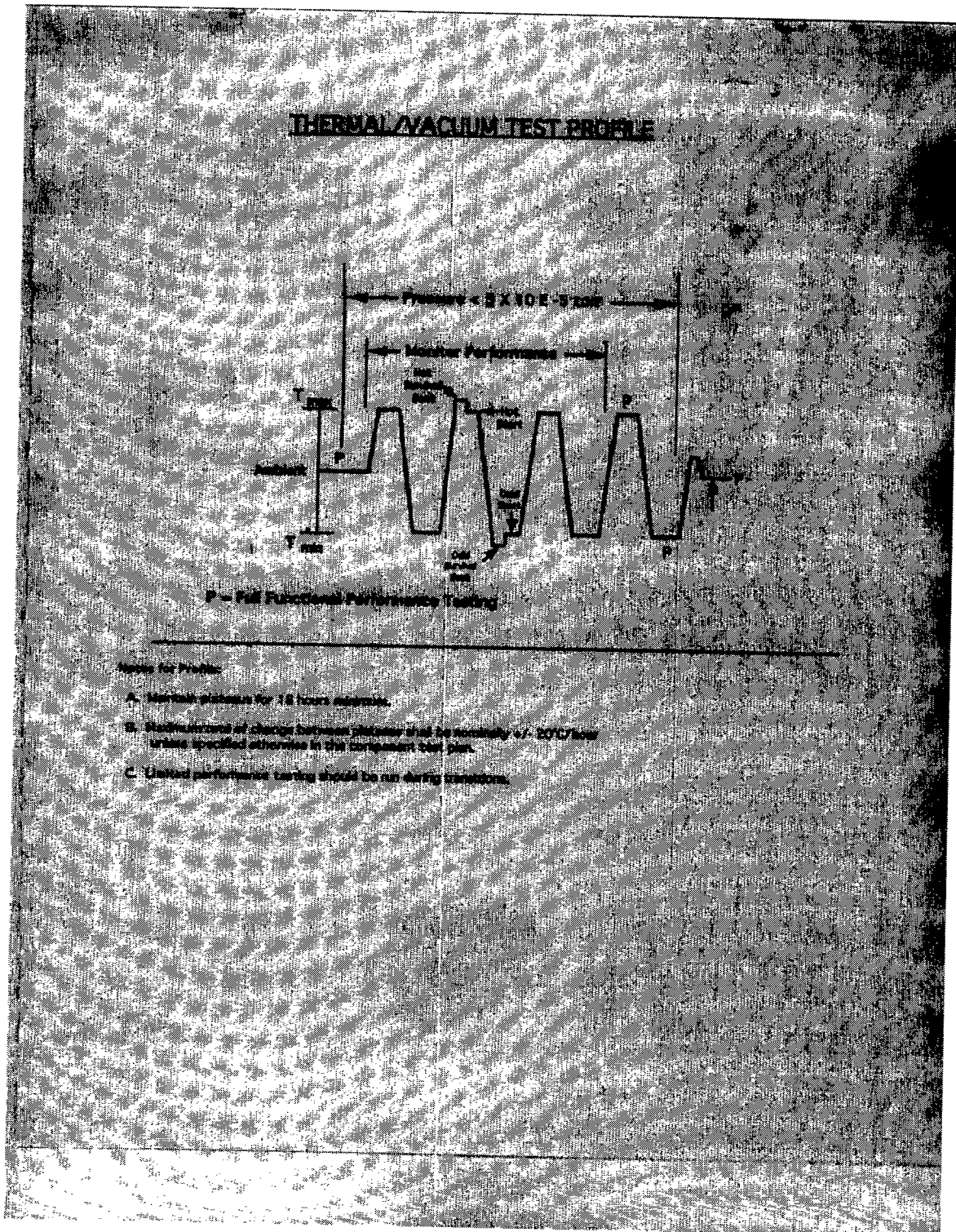
Temperature excursions during the cycling of
components shall be sufficiently large to detect
latent defects in workmanship. For components that
are determined by analysis to be insensitive to
vacuum effects relative to temperature levels and
temperature gradients, the gradient may be satisfied
by temperature cycling at normal room pressure in an
air or gaseous nitrogen environment. Additional
margin and cycles; however, are required if air
temperature is employed.

During final IAM Subsystem thermal vacuum testing,
the developer shall verify that the contamination
bake-out criteria of Section 9 of this document and
the HIRDLS Contamination Control Plan are complied
with.

3.6.1.2 <u>Flight Acceptance</u>

For the acceptance testing of previously qualified
hardware, the verification requirements apply except
that testing shall be conducted at either the
predicted mission extreme temperatures, or this
temperature plus margin to detect variations in
materials and workmanship defects, whichever is
greater.

3.6.2   Thermal Balance Design Verification

The validity of the thermal design and the ability
of the thermal control system to maintain the
hardware within the established thermal limits for
the mission shall be demonstrated by test.

The capability of the thermal control system shall
be demonstrated in the same manner. If the flight
hardware is not used in the test of the thermal
control system, verification of critical thermal
properties (such as those of the thermal control
coatings) shall be performed to demonstrate
similarity between the item tested and the flight
hardware.

3.6.2.1 <u>Flight Acceptance</u>

For the acceptance testing of previously qualified
hardware, a single point check shall be made to
verify that the thermal model adequately represents
the "as built" hardware.

3.6.3 Temperature - Humidity: Transportation and Storage

An analysis and, when necessary, tests shall demonstrate that flight hardware that is not maintained in a controlled temperature-humidity environment to within demonstrated acceptable limits, will perform satisfactorily after (or, if so required, during) exposure to the uncontrolled environment.

The test shall include exposure of the flight hardware to the following extremes of temperature and humidity:

Ten (10) degrees C and 10% RH (but not greater than 50% RH) higher and lower than those predicted for the transportation and storage environments. The exposure at each extreme shall be for a period of six (6) hours.

Bare circuit boards stored for prolonged periods of time in an uncontrolled environment must follow a test procedure approved by the SAM and Project Materials Engineer.

3.6.3.1 Acceptance Requirements

The ten (10) degree C temperature margin and the ten (10) percent RH margin may be waived for previously qualified hardware.

3.6.4 Leakage

This test shall demonstrate that leakage rates of sealed hardware are within those prescribed mission limits for the IAM; it applies to the qualification of hardware and the acceptance of hardware previously qualified.

Leakage rates shall be checked before and after stress-inducing portions of the verification program to disclose anomalies caused by the stress. The final check may be conducted during the final thermal-vacuum test.

Checks at the subsystem level need include only those items that have not demonstrated satisfactory performance at the component level or are not fully assembled until higher levels of integration.

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SECTION 4

ELECTRONIC PACKAGING AND PROCESSES REQUIREMENTS

4.1   GENERAL

The developer shall plan and implement an Electronic
Packaging and Processes Program to assure that all
electronic packaging technologies, processes, and
workmanship activities selected and applied meet EOS
Chemistry Mission objectives for quality and reliability.

4.2   WORKMANSHIP

The developer shall use the following NASA workmanship
documents:
   NASA-STD-8739.3, Soldered Electrical Connections;
   NASA-STD-8739.4, Crimping, Interconnecting
     Cables,Harnesses, and Wiring;
   Requirements for Conformal Coating and Staking of
     Printed Wiring Boards and Electronic Assemblies, NAS
     5300.4 (3J-1);
   NASA-STD-8739.7, Standard for Electrostatic Discharge
     Control (Excluding Electrically Initiated Explosive
     Devices);
   Workmanship Requirements for Surface Mount Technology,
     NAS 5300.4(3M)

The developer's alternate workmanship standards may be
used when approved by the EOS Chemistry project.

The developer shall use the following industry standards:
(1) Design Standards for Rigid and Flexible Printed
Wiring Boards, IPC 2221-2223, (2) Procurement
Specification for Rigid Printed Boards for Space
Applications and Other High Reliability Uses, GSFC S-312-
P003 (which invokes IPC 6011 and 6012).

When approved by the EOS Chemistry project, the developer
may use MIL-P-55110 as alternatives for the IPC
documents.

The developer shall provide GSFC with printed wiring
board coupons and associated test reports in accordance
with the contract. Coupons and test reports are not
required for delivery to the GSFC if the developer has
the coupons evaluated by a laboratory which has been
approved by the GSFC, in writing, before the coupons are
released for evaluation.

4.3   NEW/ADVANCED PACKAGING TECHNOLOGIES

New and/or advanced packaging technologies (e.g.,. MCMs,
stacked memories, chip on board) that have not previously

been used in space flight applications shall be reviewed and approved through the Parts Control Board (PCB) as defined in Section 5.2. New/advanced technologies shall be part of the Parts Identification List (PIL) and Program Approved Parts List (PAPL) defined in Section 5.3.

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SECTION 5

PARTS REQUIREMENTS

5.1 GENERAL

The developer shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) Parts Control Program to assure that all parts selected for use in flight hardware meet instrument objectives for quality and reliability.

The developer shall prepare a Parts Control Plan (PCP) describing the approach and methodology for implementing the Parts Control Program. The PCP shall also define the criteria for parts selection and approval based on the guidelines of this section. In addition, the PCP shall discuss the following:

1. The developer's parts control organization, identifying key individuals and specific responsibilities.

2. Detailed Parts Control Board (PCB) procedures, to include PCB membership, Designation of Chairperson, responsibilities, review and approval procedures, meeting schedules and method of notification, meeting minutes, etc.

3. Parts tracking methods and approach, including tools to be used such as databases, reports, PIL, etc. Describe the system for identifying and tracking parts approval status.

4. Parts procurement, processing and testing methodology and strategies. Identify internal operating procedures to be used for incoming inspections, screening, qualification testing, derating, testing of parts pulled from stores, Destructive Physical Analysis, radiation assessments, etc.

5. Control of what part requirements are flowed down to vendors.

6. Any "general" modifications or exceptions to the GSFC 311-INST-001 entitled "Instructions for EEE Parts Selection, Screening, and Qualification".

5.2   ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS

All part commodities identified in the GSFC Preferred Parts List (PPL) are considered EEE parts and shall be subjected to the requirements set forth in this section. Custom or advanced technology devices such as custom hybrid microcircuits, detectors, Application Specific Integrated Circuits (ASIC), and Multi-Chip Modules (MCM) shall also be subject to parts control appropriate for the individual technology (see 5.2.2.1).

5.2.1   Parts Control Board

The developer shall establish a Parts Control Board (PCB) to facilitate the management, selection, standardization, and control of parts and associated documentation for the duration of the contract. The PCB shall be responsible for the review and approval of all parts for conformance to Project requirements, and for developing and maintaining a Program Approved Parts List (PAPL).

5.2.1.1   <u>PCB Meetings</u>

PCB meetings shall be convened on a regular basis on-site at either the developer's facilities or GSFC. Use of telecons or combining PCB meetings with other scheduled meetings such as quarterlies or design reviews are highly encouraged. The developer shall prepare an agenda for all meetings. GSFC shall participate in PCB meetings, either at the meeting site or by telecon, and shall be notified at least 10 working days prior to all upcoming meetings. GSFC participation is for PCB review and approval of parts. GSFC shall have voting rights for all decisions. Lack of agreement on significant issues may require gathering of additional information and participation by subject experts at subsequent meetings. The developer shall chair all meetings, document all decisions made, and provide a copy of the meeting minutes to GSFC within three days of convening the meeting. The developer shall take care to document in the minutes all discussions and rationale for approval of parts.

The developer shall develop a PCB Operating Procedure, which may be made a part of the Parts

Control Plan. The procedure should discuss 1) membership and responsibilities, and 2) details on how meetings will be conducted (e.g. vehicle for submitting parts approval request to PCB, approval process, resolving lack of agreements, meeting frequency, etc.)

5.2.2   Parts Selection and Processing

All parts shall be selected and processed in accordance with GSFC 311-INST-001, entitled "Instructions for EEE Parts Selection, Screening, and Qualification", Parts Quality Level 2. Parts selected from the GSFC Preferred Parts List (PPL) or MIL-STD-975 "NASA Standard Electrical, Electronic, and Electromechanical Parts List" are considered to have met all criteria of GSFC 311-INST-001. These parts will be approved by the PCB provided all IAM application requirements (performance, derating, radiation, etc.) are met.

The developer's internal selection and processing documentation can be used if determined by the PCB to be consistent with GSFC 311-INST-001. Any case by case exceptions as determined by the PCB, to GSFC 311-INST-001 shall be identified in the Parts Control Board meeting minutes.

5.2.2.1 Custom Devices

Any custom microcircuits, hybrid microcircuits, MCM, ASIC, etc. planned for use by the developer shall be processed in accordance with GSFC 311-INST-001 and shall be reviewed and approved by the PCB.

5.2.3   Derating

All EEE parts shall be used in accordance with the derating guidelines of the PPL. The developer's derating policies can be used in place of the PPL guidelines and shall be presented at the PCB. The developer shall maintain documentation on parts derating analysis and shall make it available for GSFC review.

5.2.4   Radiation Hardness

All parts shall be selected to meet their intended application in the predicted mission radiation

environment. The radiation environment consists of two separate effects, those of total ionizing dose (TID)and single-event effects (SEE). The developer shall document the analysis for each part with respect to both effects. Analysis that does not qualify parts for TID and SEE shall be validated by testing requirements defined by the PCB.

5.2.5 Verification Testing

Verification of screening or qualification tests by retesting is not required unless deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. If required, testing shall be in accordance with GSFC 311-INST-001 as determined by the PCB. The developer shall be responsible for the performance of supplier audits, surveys, source inspections, witnessing of tests, and/or data review to verify conformance to established requirements.

5.2.6 Destructive Physical Analysis

A sample of each lot date code of microcircuits, hybrid microcircuits, and semiconductor devices shall be subjected to a Destructive Physical Analysis (DPA). All other part types may require a sample DPA if it is deemed necessary as indicated by failure history, GIDEP Alerts, or other reliability concerns. Sample DPA shall not be required for Class S or equivalent microcircuits, and semiconductors procured to military specifications or Standard Military Drawings (SMDs). The Parts Control Board (PCB) may decide, on a case by case basis, whether any other part lot need not be subjected to DPA or to modify DPA requirements based on parts usage, testing or manufacturing history. Appropriate rationale shall be recorded in the PCB meeting minutes or other documented form. DPA tests, procedures, sample size and criteria shall be as specified in GSFC specification S-311-M-70, "Destructive Physical Analysis". The developer's procedures for DPA may be used in place of S-311-M-70 and shall be submitted for review with the Parts Control Plan (PCP). Variation to the DPA sample size requirements, due to part complexity, availability or cost, shall be determined and approved by the PCB. In the event that the PCB does not unanimously concur on the DPA sample size or modifications to requirements for any part lot, the

developer may raise the issue to the Project via the waiver/deviation process.

5.2.7   Parts Age Control

Parts drawn from controlled storage after 5 years from the date of the last full screen shall be subjected to a 100 percent visual examination and electrical testing at room temperature, as a minimum. Additional testing, including DPA, shall be determined by the PCB as deemed necessary. Parts stored in other than controlled conditions where they are exposed to the elements or sources of contamination shall not be used.

5.3   PARTS LISTS

The developer shall create and maintain a Program Approved Parts List (PAPL) and a Parts Identification List (PIL) for the duration of the program. The developer may choose to incorporate the PAPL and PIL into one list, which shall be submitted to GSFC as a PIL, provided clear distinctions are made as to parts approval status and whether parts are planned for use in flight hardware. An as-built PIL shall be included as part of the Acceptance Data Package.

5.3.1   Program Approved Parts List

The Program Approved Parts List (PAPL) shall be the only source of approved parts for flight hardware, and as such may contain parts not actually in flight design. Only parts that have been evaluated and approved by the PCB shall be listed in the PAPL. Parts must be approved for listing on the PAPL before initiation of procurement activity. The criteria for PAPL listing shall be based on GSFC 311-INST-001 and as specified herein (see 5.2.2). The PCB shall assure standardization and the maximum use of parts listed in the PAPL. The PAPL and all subsequent revisions shall be available for GSFC review upon request.

5.3.2   Parts Identification List

As opposed to the PAPL, the Parts Identification List (PIL) shall list all parts planned for use in flight hardware. The as-designed PIL and subsequent updates shall be reviewed by GSFC during

the PCB. In addition, the as-designed list will be discussed at the instrument PDR and CDR and shall be provided to GSFC upon request.

5.4   ALERTS

The contractor shall be responsible for reviewing all Government Industry Data Exchange Program (GIDEP) Alerts for applicability to the parts proposed for use. GIDEP Alert impact and corrective actions shall be documented and made available for GSFC review.

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SECTION 6

MATERIALS, PROCESSES AND LUBRICATION REQUIREMENTS

6.1 GENERAL REQUIREMENTS

The developer shall implement comprehensive Materials and Processes Plan beginning at the design stage of the IAM subsystem that meets the contamination levels of the Chemistry Observatory. The program shall help ensure the success and safety of the mission by the appropriate selection, processing, inspection, and testing of the materials and lubricants employed to meet the operational requirements for OMI IAM. Materials and lubrication assurance information is required for each usage or application in the IAM. The developer shall provide an open loop of communication to the GSFC Materials Assurance Engineer to ensure there is adequate materials usage information to approve each materials usage or application on the IAM. The as-designed materials list can be just one list that includes the lubrication, polymeric, and inorganic materials along with a list of the processes expected for use. This as-designed list shall be available to GSFC upon request and shall be presented at the PDR and CDR. An as-built materials and processes list shall be submitted as part of the instrument Acceptance Data Package.

6.2 MATERIALS SELECTION REQUIREMENTS

In order to anticipate and minimize materials problems during space hardware development and operation, the developer shall, when selecting materials and lubricants, consider potential problem areas such as radiation effects, thermal cycling, stress corrosion cracking, galvanic corrosion, hydrogen embrittlement, lubrication, contamination of cooled surfaces, composite materials, atomic oxygen, useful life, vacuum outgassing, flammability and fracture toughness, as well as the properties required by each material usage or application.

6.2.1 Compliant Materials

The developer shall use compliant materials in the fabrication of flight hardware to the extent practicable.

In order to be compliant, a material must be used in a conventional application and meet the ELV criteria identified in Table 6.1.

6.2.2 Noncompliant Materials

A material that does not meet the ELV requirements of Table 6.1, or meets the ELV requirements of Table 6.1 but is used in an unconventional application shall be considered to be a noncompliant material. The developer shall provide an open loop of communication for the GSFC Materials Engineer to assess and recommend approval of the noncompliant materials.

6.2.2.1 Materials Used in "Off-the-Shelf-Hardware"

"Off-the-shelf hardware" for which a detailed materials list is not available and where the included materials cannot be easily identified and/or changed shall be treated as noncompliant. The developer shall define what measures will be used to ensure that all materials in the hardware are acceptable for use. Such measures might include any one, or a combination, of the following: hermetic sealing, vacuum bakeout, material changes for known noncompliant materials, etc. When a vacuum bakeout is the selected method, it must incorporate a quartz crystal microbalance (QCM) and cold finger to enable a determination of the duration and effectiveness of the bakeout as well as compliance with the instrument contamination plan.

6.2.3 Conventional Applications

Conventional applications or usage of materials is the use of compliant materials in a manner for which there is extensive satisfactory aerospace heritage.

6.2.4 Nonconventional Applications

The proposed use of a compliant material for an application for which there is limited satisfactory aerospace usage shall be considered a non-conventional application. In that case, the material usage shall be verified for the desired application on the basis of test, similarity, analyses, inspection, existing data, or a combination of those methods. This information shall be provided to the GSFC Material Assurance Engineer during design reviews or other project meetings.

6.2.5 Polymeric Materials

The developer shall document a polymeric materials
and composites usage list. Material acceptability
shall be determined on the basis of flammability,
vacuum outgassing and all other materials properties
relative to the application requirements and usage
environment. The polymeric material list shall be
included as part of the as-designed list submitted
by the developer. A separate list is not required.

6.2.5.1 Flammability

Expendable Launch Vehicle (ELV) payload materials
shall meet the requirements of EWR 127-1, Paragraph
3.10.1.

TABLE 6-1
MATERIAL SELECTION CRITERIA

Type Launch	Payload Location	Flammability	Vacuum Outgassing	Stress Corrosion Cracking (SCC)
ELV	All	Note 3	Note 4	Note 5

NOTES:

1. Flammability requirements as defined in NHB 8060.1.

2. Flammability requirements specified in NHB 1700.7, Paragraph 209.

3. Flammability requirements specified in EWR 127-1, Paragraph 3.10.1.

4. Vacuum Outgassing requirements as defined in paragraph 6.2.5.2.

5. Stress corrosion cracking requirements as defined in MSFC-SPEC-522.

6.2.5.2 Vacuum Outgassing

Material vacuum outgassing shall be determined in
accordance with ASTM E-595. A material is
qualified on a product-by-product basis. GSFC may
require lot testing of any material for which lot
variation is suspected. In such cases, material
approval is contingent upon lot testing. Only
materials that have a total mass loss (TML) <1.00%

and a collected volatile condensable mass (CVCM) <0.10% will be approved for use in a vacuum environment unless a waiver is submitted and granted by EOS Chemistry project.

6.2.5.3 <u>Shelf-Life-Controlled Materials</u>

Polymeric materials that have a limited shelf-life shall be controlled by a program that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. Materials such as o-rings, rubber seals, tape, uncured polymers, lubricated bearings and paints shall be included. The use of materials whose date code has expired requires that the developer demonstrate by means of appropriate tests that the properties of the materials have not been compromised for their intended use; such materials must be approved by EOS Chemistry project by means of a waiver. All limited-life items, including piece part in subassemblies, shall be included in the instrument Limited-Life list as part of the Acceptance Data Package.

6.2.6 Inorganic Materials

The developer shall document an inorganic materials and composites usage list. When requested, the developer shall provide supporting applications data. The criteria specified in MSFC-SPEC-522 shall be used to determine that metallic materials meet the stress corrosion cracking criteria. The GSFC Materials Assurance Engineer shall have verbal discussions with the developer for each material usage that does not comply with the MSFC-SPEC-522 stress corrosion cracking requirements. Nondestructive evaluation requirements are contained the ELV structure integrity requirements. The inorganic material list shall be included as part of the as-designed list submitted by the developer. A separate list is not required.

6.2.6.1 <u>Fasteners</u>

The developer shall comply with the procurement documentation and test requirements for flight hardware and critical ground support equipment fasteners contained in GSFC S-313-100, Goddard Space Flight Center Fastener Integrity Requirements.

Fasteners made of plain carbon or low alloy steel shall be protected from corrosion. When plating is specified, it shall be compatible with the space

environment. On steels harder than RC 33, plating shall be applied by a process that is not embrittling to the steel.

6.2.7 Lubrication

The developer shall document a lubrication usage list. When requested, the developer shall provide supporting applications data.

Lubricants shall be selected for use with materials on the basis of valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination effects.

All lubricated mechanisms shall be qualified by life testing in accordance with a life test plan or heritage of an identical mechanism used in identical applications.

6.3 PROCESS SELECTION REQUIREMENTS

The developer shall prepare a material process utilization list. When requested, a copy of any process shall be made available to GSFC. Manufacturing processes (e.g., lubrication, heat treatment, welding, chemical or metallic coatings), shall be carefully selected to prevent any unacceptable material property changes that could cause adverse effects of materials applications.

6.4 PROCUREMENT REQUIREMENTS

6.4.1 Purchased Raw Materials

Raw materials purchased by the developer shall be accompanied by the results of nondestructive, chemical and physical tests, or a Certificate of Compliance.

6.4.2 Raw Materials Used in Purchased Products

The developer shall require that the suppliers meet the requirements of 6.4.1 and provide on request the results of acceptance tests and analyses performed on raw materials.

SECTION 7

RELIABILITY REQUIREMENTS

7.1   GENERAL REQUIREMENTS

The developer shall plan and implement a reliability program that interacts effectively with other program disciplines, including systems engineering, hardware design, and product assurance. The program shall be tailored according to:

a. Demonstrate that redundant functions, including alternative paths and work-arounds, are independent to the extent practicable.

b. Demonstrate that stress applied to parts is not excessive.

c. Show that reliability design is in keeping with mission design life and that it is consistent among components, subsystems and the instrument.

d. Identify limited-life items and ensure that special precautions are taken to conserve their useful life for on-orbit operations.

7.2   RELIABILITY ANALYSES

Reliability analyses shall be performed concurrently with design so that identified problem areas can be addressed for timely consideration of corrective action.

7.2.1   Failure Modes and Effects Analysis and Critical Items List

A Failure Modes and Effects Analysis (FMEA) shall be performed early in the design phase to identify system design problems. As additional design information becomes available the FMEA shall be refined.

Failure modes shall be assessed at the component interface level. Each failure mode shall be assessed for the effect at that level of analysis, the next higher level and upward. The failure mode shall be assigned a severity category based on the most severe effect caused by a failure.

Severity categories shall be determined in accordance with Table 7-1:

TABLE 7-1

SEVERITY CATEGORIES

Category	Severity Definition
1	Catastrophic Failure modes that could result in serious injury or loss of life (flight or ground personnel), or loss of launch vehicle.
1R	Failure modes of identical or equivalent redundant hardware items that, if all failed, could result in category 1 effects.
1S	Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and leads to Severity Category 1 consequences.
2	Critical Failure modes that could result in loss of one or more mission objectives as defined by the EOS Chemistry project office.
2R	Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant Failure modes that could cause degradation to mission objectives.
4	Minor Failure modes that could result in insignificant or no loss to mission objectives.

FMEA analysis procedures and documentation shall be performed in accordance with accepted practices. Failure modes resulting in Severity Categories 1, 1R, 1S or 2 shall be analyzed at greater depth, to the single parts if necessary, to identify the cause of failure.

Results of the FMEA shall be used to evaluate the design relative to requirements. Identified discrepancies shall be evaluated by the developer's management and design groups for assessment of the need for corrective action. No single failure shall prevent removal of power from the IAM Subsystem.

The FMEA shall analyze redundancies to ensure that redundant paths are isolated or protected such that any single failure that causes the loss of a functional path shall not affect the other functional path(s) or the capability to switch operation to that redundant path.

All failure modes that are assigned to Severity Categories 1, 1R, 1S and 2, shall be itemized on a Critical Items List (CIL) and discussed during the instrument design reviews. Rationale for retaining the items shall be included on the CIL.

7.2.2 Parts Stress Analyses

Each application of electrical, electronic, and electromechanical (EEE) parts shall be subjected to stress analyses for conformance with the applicable derating guidelines (see section 5.2.3). The analyses shall be performed at the most stressful values that result from specified performance and environmental requirements (e.g. temperature, voltage) on the assembly or component. The analyses shall be performed in close coordination with the internal component reviews and thermal analyses, and it shall be required input data for component-level design reviews. The analysis results shall be presented at the instrument design reviews.

7.2.3 Reliability Assessments

The developer shall perform reliability assessments to:

(a) evaluate alternative design concepts, redundancy and cross-strapping approaches, and part substitutions; and identify the elements of the design which are the greatest detractors of system reliability;

(b) identify those potential mission limiting elements and components that will require special attention in part selection, testing, environmental isolation, and/or special operations;

(c) assist in evaluating the ability of the design to achieve the mission life requirement and other reliability goals and requirements as applicable; and

(d) evaluate the impact of proposed engineering change and waiver requests on reliability.

The developer shall integrate reliability assessments with the design process and other assurance practices. Also, the developer shall describe how the reliability assessments will incorporate definitions of failure as well as alternate and degraded operating modes that clearly describe plausible acceptable and unacceptable levels of performance. Degraded operating modes shall include failure conditions that could be alleviated or reduced in significance through the implementation of work-arounds, via telemetry.

The results of reliability assessments shall be reported at instrument PDR and CDR.

7.3 ANALYSIS OF TEST DATA

The developer shall fully utilize test information during the normal test program to assess flight equipment reliability performance and identify potential or existing problem areas. These problem areas shall be documented and directed to the attention of the developer's management for action.

7.4 LIMITED LIFE ITEMS

Limited life items shall be identified during the design reviews. A limited life items list shall be included as part of the instrument Acceptance Data Package. This list shall include the expected life and the rationale for the selection of each limited-life item.

7.5 Single Point Failures

Single point failures (SPF) and their mitigation strategies shall be identified during the design reviews. A SPF list shall be included as part of the Acceptance Data Package. This list shall include all SPF and the mitigation rationale for each.

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SECTION 8

QUALITY ASSURANCE REQUIREMENTS

8.0 QUALITY MANAGEMENT SYSTEM

The developer shall have a Quality Management System which shall be compliant with ANSI/ASQC Q9001-1994, and Third Party registered.

8.1 QA MANAGEMENT SYSTEM REQUIREMENTS AUGMENTATION

The following requirements augment identified portions of ANSI/ASQC Q9001-1994.

8.1.1 Paragraph 4.13.2 of ANSI/ASQC Q9001-1994 is augmented as follows:

A problem/failure report (PFR) shall be written, and provided to the GSFC Systems Assurance Manager, for any departure from design, performance, testing, or handling requirement that affects the function of flight equipment, ground support equipment that interfaces with flight equipment, or that could compromise mission objectives.

This reporting shall continue through formal acceptance by GSFC. For software problems, failure reporting shall begin with the first test use of the software item with the flight hardware. In addition, the developer shall maintain PFR records of problems encountered at the lower levels of assembly.

SECTION 9
CONTAMINATION CONTROL REQUIREMENTS

9.1   GENERAL

The developer shall plan and implement a contamination control program applicable to the OMI IAM Subsystem. The program establishes the specific cleanliness requirements and delineates the approaches in a Contamination Control Plan (CCP).

9.2   CONTAMINATION CONTROL PLAN

The developer shall prepare and submit a CCP that describes the procedures that will be followed to control contamination. The CCP shall define a contamination allowance for performance degradation of contamination sensitive hardware such that, even in the degraded state, the IAM will meet its mission objectives. The CCP shall establish the implementation and describe the methods that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the instrument's lifetime.

9.3   MATERIAL OUTGASSING

All materials shall be screened in accordance with NASA Reference Publication 1124. A list of material outgassing data shall be established and reviewed by the GSFC Materials Assurance Engineer.

9.4   THERMAL VACUUM BAKEOUT

Bake-outs of wiring harnesses and thermal blankets are required since past experience has shown these to be major contributors to the contamination level of hardware in test and flight. During these bake-outs, the outgassing must be measured to ensure compliance with the allowances in Section 9.2. The parameters (e.g. verification method, temperature, duration, pressure) of such bake-outs must be individualized, depending on the materials used, the fabrication environment, and the established contamination allowance. The bake-out parameters for each hardware item shall be documented in individual bake-out specifications and referenced in the CCP.

The developer shall incorporate a quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger during all thermal vacuum bakeouts. These devices shall

provide additional information to enable a
determination of the duration and effectiveness of
the thermal vacuum bakeout as well as compliance
with the instrument contamination control plan.

9.5 HARDWARE HANDLING

The developer shall practice cleanroom standards in
handling hardware. The contamination potential of
material and equipment used in cleaning, handling,
packaging, tent enclosures, shipping containers,
bagging (e.g., antistatic film materials), and
purging shall be addressed.

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SECTION 10

SOFTWARE ASSURANCE REQUIREMENTS

10.1   GENERAL

The developer shall develop a software management plan which covers both flight and ground software. This plan shall be in accordance with GSFC 424-28-11-01 entitled "Instrument Software Management Requirements Document". Software assurance activities shall also be discussed in this plan.

The developer will hold internal software reviews at appropriate times in the program and will notify GSFC as to where and when these reviews will be held. The developer will formally present the software requirements at the time of the hardware PDR, and will report the software design information with the hardware CDR. The software test readiness and acceptance will formally be reported at the PER and PSR respectively.

The corrective action process shall start at the establishment of a Configuration Management baseline that includes the product. In no case shall the use of the formal software corrective action process be delayed beyond the use of the software in hardware for which formal problem reporting is required.

The GSFC shall be allowed access to the problem reports and the corrective action information as they are developed.

The developer shall establish a Software Configuration Management (SCM) baseline after each formal software review. Software products shall be placed under Configuration Management immediately after the successful conclusion of the review. The developer's SCM system shall have a change classification and impact assessment process that results in Class 1 changes being forwarded to EOS Chemistry project for disposition. Class 1 changes are defined as major changes which affect mission requirements, system safety, reliability, cost, schedule, and external interfaces.

10.2　GFE, EXISTING AND PURCHASED SOFTWARE

If the developer is using existing or purchased software, then the developer is responsible for the software meeting the functional, performance, and interface requirements placed upon it. The developer is responsible for ensuring that the software meets all applicable standards, including those for design, code, and documentation. Any significant modification to any piece of the existing software shall be subjected to all of the provisions of the developer's Software Management Plan and the provisions of this document. A significant modification is defined as the change of twenty percent of the lines of code in the software.

10.3　SOFTWARE SAFETY

If any software component is identified as safety critical, the developer shall conduct a software safety program on that component that complies with NSS 1740.13 "Software Safety Standard", and Sections 3.16 of EWR 127-1 (Tailored).

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SECTION 11

SAFETY REQUIREMENTS

11.1   GENERAL REQUIREMENTS

The developer shall plan and conduct a system safety program for the IAM Subsystem, supplied ground support equipment for the IAM, and supplied ground support equipment (GSE) that accomplishes the following:

a.   Provides for the identification and control of hazards to personnel, facilities, support equipment, and flight systems during all stages of IAM development and integration with the OMI Instrument System and spacecraft including launch activities. The program shall also consider hazards in the flight hardware, software, associated equipment, and potential malfunctions in the IAM GSE that may affect the OMI Instrument System and spacecraft.

b.   Satisfies the applicable guidelines, constraints, and requirements stated in the revisions of the following document current at the time of Contract Award:

Eastern & Western Range Safety Policies & Processes, EWR 127-1 (Tailored).

c.   Interfaces effectively with the industrial safety requirements of the contract and the developer existing safety programs.

11.2   SYSTEM SAFETY IMPLEMENTATION PLAN (SSIP)

The developer shall prepare a System Safety Implementation Plan (SSIP) which describes the safety program requirements, the plan for implementing them, and shall reference detailed procedures to ensure the identification and control of hazards to personnel and hardware during fabrication, tests, transportation, ground activities, launch, and mission operations.

The plan shall address the following areas:

a.   System safety organization, interfaces, and responsibilities
b.   System safety methodologies
c.   Internal and external safety review process
d.   Launch site safety
e.   Verification and operating procedures
f.   Hazardous operation surveillance
g.   Accident investigation and reporting
h.   Operator training and certification

i. Safety audits
j. Documentation to be provided
k. Milestone schedule of all major system safety activities which shows their time phasing with other related major activities
l. Procedure for reporting problems and activity status
m. The industrial safety program responsibilities, functions, and interfaces with system safety program.

The SSIP shall be available for review upon request. Reporting shall be provided to GSFC at PER and the final SSIP at PSR. Also, all referenced documents in the SSIP shall be included with the plan.

11.3   STRUCTURAL INTEGRITY AND FRACTURE CONTROL

Verification of the structural integrity of the OMI IAM Subsystem is required. When protoflight testing to verify the structural design is conducted, no further verification of fracture control is required. Where such testing is not required, or for follow-on hardware (which is not normally subjected to protoflight testing), the developer shall verify structural integrity by subjecting the flight hardware to an appropriate series of proof loads tests to limit levels.

11.4   ANALYSIS

11.4.1 Hazard Analysis

Early in the design phase, the developer shall perform hazard analyses to identify any potential hazards originating from the IAM Subsystem or the developer provided GSE. The analyses shall be performed at the component and Subsystem levels and shall identify all hazards affecting personnel, IAM GSE, and the OMI Instrument System. The analyses shall be oriented to the requirements/hazards areas identified in Chapters 3 and 6 of EWR 127-1 (Tailored) and shall provide all information necessary to complete the hazard identification and elimination/control requirements of the "Safety Assessment Report" (SAR). A separate Payload Hazard Report shall be generated for each hazard identified. The hazard report shall document the causes, controls, verification methods, and status of verification for each hazard.

Throughout the OMI IAM development effort, the developer shall take measures to eliminate or to

minimize the effects of each hazard identified. The hazard analysis and reports shall be updated as the hardware progresses through the stages of design, fabrication, test transportation, integration, and launch. The hazard analysis reports shall be included with the Safety Assessment Reports submittals.

Summaries of the Hazard Analysis Reports and the status of hazard control efforts shall be reported at the design and readiness reviews (see section 11.7).

11.4.2 Operation Hazard Analysis

When the use of a facility or when the performance of an activity could result in subjecting the IAM or personnel to hazards, an Operations Hazard Analysis (OHA) shall be performed to identify the hazards and document the requirements for either eliminating or adequately controlling each hazard. Operations that may require analyses include handling, transportation, functional tests, and environmental test. A report of each OHA performed shall be available to GSFC upon request.

11.5 HAZARD CONTROL VERIFICATION

Verification of the control of all hazards shall be accomplished by test, analysis, inspection, similarity to previously qualified hardware, or any combination of these activities. Reports of such verifications performed by the developer shall be incorporated in the Hazard Analysis Reports (see section 11.4.1).

11.6 PROCEDURE APPROVAL

The developer's safety engineer shall review and approve all procedures affecting flight hardware and provided GSE. Hazardous operations shall be identified and procedures to control them shall be developed and implemented.

11.7 REVIEWS

The OMI IAM safety status shall be examined at the GSFC Design Reviews as well as the other applicable Air Force Space Command Western Range (WR) safety reviews. The developer shall submit the current safety data at the time of the GSFC PDR, CDR, PER and all flight readiness reviews, as well as the WR phased safety reviews. The WR reviews are required

as described in Appendix 1B of EWR 127-1 at the following instrument milestones:

Phase 1 - Around the time of GSFC PDR

Phase 2 - Around the time of GSFC CDR

Phase 3 - 90 days prior to shipping the instrument to the spacecraft contractor.

The developer shall provide data inputs required by the WR, and technical support to the NASA project office for all safety reviews.

11.8   SAFETY DEVIATION/WAIVER

When a specific safety requirement can not be met, the developer shall submit a deviation/waiver request (DOD Form 1964). The deviation/waiver request shall state the requirement that cannot be met, the reason it cannot be met, the proposed method of controlling the additional risk, and the residual risk after application of the additional controls. Each deviation/waiver request shall address only one hazard and shall be submitted as soon as it is determined that one is required. EWR 127-1 requires that each phased safety review address any deviation/waiver requests that may have been generated. Safety deviation/waiver requests shall be submitted to the Project Safety Manager.

11.9   SAFETY ASSESSMENT REPORT (SAR)

The developer shall submit to NASA a Safety Assessment Report relative to the instrument which complies with the requirements of section 3.4.1.2 of EWR 127-1 (see par. 11.4.1, herein), for an SAR prior to each of the WR phased safety reviews (see section 11.7 herein). The content of the package shall be appropriate to the phase of the program at the time of delivery and shall include the Payload Hazard Reports (see sections 11.4.1 and 11.5). The developer shall include with the SAR, copies of any pertinent deviation/waiver requests that have been generated (see section 11.8 above) and shall update the SAR as necessary.

11.10   FLAMMABILITY

Flammability hazards shall be minimized in the selection and application of materials in the design. Where any flammable materials must be used, the following hazard elimination and control

requirements apply: (a) two failure tolerance on ignition sources, (b) physical separation of the flammable material from ignition sources, and (c) elimination of flame propagation paths.

SECTION 12

APPLICABLE DOCUMENTS

ANSI/ASQC Q9001-1994	Model for Quality Assurance in Design, Development, Production, Installation, and Servicing
IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
ASTM E-595	Total Mass Loss (TML) and Collected Volatile Condensable Materials (CVCM) from Outgassing in a Vacuum Environment
EWR 127-1 (Tailored)	Eastern and Western Range Safety Requirements (As tailored for the EOS Common Spacecraft Projects)
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components, rev A, dated June 1996
GSFC 422-11-12-01	General Interface Requirements Documenet (GIRD) for EOS Common Spacecraft
GSFC 424 -28-11-01	Instrument Software Management Requirements Document for EOS Chemistry

GSFC 311-INST-001	Instructions for EEE Parts Selection, Screening, and Qualification
GSFC PPL	Goddard Space Flight Center Preferred Parts List
GSFC S-312-P003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
MIL-STD 1629A	Procedures for Performing a Failure Mode Effects and Criticality Analysis
MIL-STD-756B	Reliability Modeling and Prediction
MIL-STD-975	NASA Standard Electrical, Electronic, and Electromechanical (EEE) Parts List
MSFC CR 5320.9	Payload and Experiment Failure Mode Effects Analysis and Critical Items List Groundrules
MSFC-HDBK-527	Material Selection List for Space Hardware Systems
MSFC-SPEC-522	Design Criteria for Controlling Stress Corrosion Cracking
NASA-STD-8739.4	Crimping, Interconnecting Cable Harnesses, and Wiring

NAS 5300.4(3J-1)	Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies
NAS 5300.4(3M)	Workmanship Requirements for Surface Mount Technology
NASA Reference Publication (RP) 1124	Outgassing Data for Selecting Spacecraft Materials
NASA RP-1161	Evaluation of Multilayer Printed Wiring Boards by Metallographic Techniques
NASA-STD-8739.3	Soldered Electrical Connections
NASA-STD-8739.7	Standard for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)
NHB 8060.1	Flammability, Odor, and Offgassing Requirements and Test Procedures for Materials in Environments That Support Combustion
NSS 1740.13	Software Safety Standard
NSTS 22648	Flammability Configuration Analysis for Spacecraft Applications
S-302-89-01	Procedures for Performing a Failure Mode and Effects Analysis (FMEA)
S-311-M-70	Specification for Destructive Physical Analysis

SECTION 13

ACRONYM LIST
&
DEFINITIONS

ACRONYMS

ABPL	As-Built Parts List
ANSI	American National Standards Institute
AR	Acceptance Review
ASQC	American Society for Quality Control
ASIC	Application Specific Integrated Circuits
BOL	Beginning of Life
C	Celsius
CCP	Contamination Control Plan
CDR	Critical Design Review
CDRL	Contract Delivery Requirements List
CIL	Critical Items List
CPT	Comprehensive Performance Test
CVCM	Collected Volatile Condensable Mass
DoD	Department of Defense
DPA	Destructive Physical Analysis
DRP	Design Review Program
DRT	Design Review Team
EEE	Electrical, Electronic, and Electromechanical
ELV	Expendable Launch Vehicle
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EOL	End of Life
FMEA	Failure Modes and Effects Analysis
GEVS-SE	General Environmental Verification Specification for STS & ELV Payloads, Subsystems, and Components
GFE	Government-Furnished Equipment
GIA	Government Inspection Agency
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
IAC	Independent Assurance Contractor
IAM	Interface Adapter Module
ICD	Interface Control Document
LPT	Limited Performance Test
MAG	Mission Assurance Guidelines
MCM	Multi-Chip Module
MO&DSD	Mission Operations and Data Systems Directorate
MSFC	Marshall Space Flight Center
MUA	Materials Usage Agreement
NAS	NASA Assurance Standard
NASA	National Aeronautics and Space Administration
Nascom	NASA Communications Network
NHB	NASA Handbook
NSTS	National Space Transportation System
OMI	Ozone Monitoring Instrument
OSSMA	Office of Systems Safety and Mission Assurance
PAPL	Program Approved Parts List

PCB	Parts Control Board
PCP	Parts Control Plan
PDR	Preliminary Design Review
PER	Pre-Environmental Review
PFR	Problem/Failure Report
PI	Principal Investigator
PIL	Parts Identification List
POCC	Payload Operations Control Center
PPL	Preferred Parts List
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QCM	Quartz Crystal Microbalance
RFA	Request for Action
RH	Relative Humidity
SCC	Stress Corrosion Cracking
SCD	Source Control Drawing
SCM	Software Configuration Management
SCR	System Concept Review
SOW	Statement of Work
SRO	Systems Review Office
TML	Total Mass Loss
TR	Torque Ratio

DEFINITIONS

The following definitions apply within the context of this document:

Acceptance Tests: The verification process that demonstrates that hardware is acceptable for flight. It also serves as a quality control screen to detect deficiencies and, normally, to provide the basis for delivery of an item under terms of a contract.

Assembly: See Level of Assembly.

Audit: A review of the developer's, contractor's or subcontractor's documentation or hardware to verify that it complies with project requirements.

Collected Volatile Condensable Material (CVCM): The quantity of outgassed matter from a test specimen that condenses on a collector maintained at a specific constant temperature for a specified time.

Component: See Level of Assembly.

Configuration: The functional and physical characteristics of the payload and all its integral parts, assemblies and systems that are capable of fulfilling the fit, form and functional requirements defined by performance specifications and engineering drawings.

Configuration Control: The systematic evaluation, coordination, and formal approval/disapproval of proposed changes and implementation of all approved changes to the design and production of an item the configuration of which has been formally approved by the contractor or by the purchaser, or both.

Configuration Management: The systematic control and evaluation of all changes to baseline documentation and subsequent changes to that documentation which define the original scope of effort to be accomplished (contract and reference documentation) and the systematic control, identification, status accounting and verification of all configuration items.

Contamination: The presence of materials of molecular or particulate nature that degrade the performance of hardware.

Derating: The reduction of the applied load (or rating) of a device to improve reliability or to permit operation at high ambient temperatures.

Design Specification: Generic designation for a specification that describes functional and physical requirements for an article, usually at the component level or higher levels of assembly. In its initial form, the design specification is a statement of functional requirements with only general coverage of physical and test requirements. The design specification evolves through the project life cycle to reflect progressive refinements in performance, design, configuration, and test requirements. In many projects the end-item specifications serve all the purposes of design specifications for the contract end-items. Design specifications provide the basis for technical and engineering management control.

Designated Representative: An individual (such as a NASA plant representative), firm (such as assessment contractor), Department of Defense (DOD) plant representative, or other government representative designated and authorized by NASA to perform a specific function for NASA. As related to the contractor's effort, this may include evaluation, assessment, design review, participation, and review/approval of certain documents or actions.

Destructive Physical Analysis (DPA): An internal destructive examination of a finished part or device to assess design, workmanship, assembly, and any other processing associated with fabrication of the part.

Design Qualification Tests: Tests intended to demonstrate that the test item will function within performance specifications under simulated conditions more severe than those expected from ground handling, launch, and orbital operations. Their purpose is to uncover deficiencies in design and method of manufacture. They are not intended to exceed design safety margins or to introduce unrealistic modes of failure. The design qualification tests may be to either "prototype" or "protoflight" test levels.

Discrepancy: See Nonconformance

Electromagnetic Compatibility (EMC): The condition that prevails when various electronic devices are performing their functions according to design in a common electromagnetic environment.

Electromagnetic Susceptibility: Undesired response by a component, subsystem, or system to conducted or radiated electromagnetic emissions.

End-to-End Tests: Tests performed on the integrated ground and flight system, including all elements of the payload, its control, stimulation, communications, and data processing to demonstrate that the entire system is operating in a manner to fulfill all mission requirements and objectives.

Failure: A departure from specification that is discovered in the functioning or operation of the hardware or software. See nonconformance.

Failure Modes and Effects Analysis (FMEA): A procedure by which each credible failure mode of each item from a low indenture level to the highest is analyzed to determine the effects on the system and to classify each potential failure mode in accordance with the severity of its effect.

Flight Acceptance: See Acceptance Tests.

Fracture Control Program: A systematic project activity to ensure that a payload intended for flight has sufficient structural integrity as to present no critical or catastrophic hazard. Also to ensure quality of performance in the structural area for any payload project. Central to the program is fracture control analysis, which includes the concepts of fail-safe and safe-life, defined as follows:

a.   **Fail-safe**: Ensures that a structural element, because of structural redundancy, will not cause collapse of the remaining structure or have any detrimental effects on mission performance.

b.   **Safe-life**: Ensures that the largest flaw that could remain undetected after non-destructive examination would not grow to failure during the mission.

Functional Tests: The operation of a unit in accordance with a defined operational procedure to determine whether performance is within the specified requirements.

Hardware: As used in this document, there are two major categories of hardware, as follows:

a. **Prototype Hardware:** Hardware of a new design; it is subject to a design qualification test program; it is not intended for flight.

b. **Flight Hardware:** Hardware to be used operationally in space. It includes the following subsets:

    (1) **Protoflight Hardware:** Flight hardware of a new design; it is subject to a qualification test program that combines elements of prototype and flight acceptance verification; that is, the application of design qualification test levels and flight acceptance test durations.

    (2) **Follow-On Hardware:** Flight hardware built in accordance with a design that has been qualified either as prototype or as protoflight hardware; follow-on hardware is subject to a flight acceptance test program.

    (3) **Spare Hardware:** Hardware the design of which has been proven in a design qualification test program; it is subject to a flight acceptance test program and is used to replace flight hardware that is no longer acceptable for flight.

    (4) **Reflight Hardware:** Flight hardware that has been used operationally in space and is to be reused in the same way; the verification program to which it is subject depends on its past performance, current status, and the upcoming mission.

Inspection: The process of measuring, examining, gauging, or otherwise comparing an article or service with specified requirements.

Instrument: See Level of Assembly.

Level of Assembly: The environmental test requirements of GEVS generally start at the component or unit level assembly and continue hardware/software build through the system level (referred to in GEVS as the payload or spacecraft level). The assurance program includes the part level. Verification testing may also include testing at the assembly and subassembly levels of assembly; for test record keeping these levels are

combined into a "subassembly" level. The
verification program continues through launch, and
on-orbit performance. The following levels of
assembly are used for describing test and analysis
configurations:

Assembly: A functional subdivision of a
component consisting of parts or subassemblies
that perform functions necessary for the
operation of the component as a whole. Examples
are a power amplifier and gyroscope.

Component: A functional subdivision of a
subsystem and generally a self-contained
combination of items performing a function
necessary for the subsystem's operation.
Examples are electronic box, transmitter, gyro
package, actuator, motor, battery. For the
purposes of this document, "component" and
"unit" are used interchangeably.

Instrument: A spacecraft subsystem consisting
of sensors and associated hardware for making
measurements or observations in space. For the
purposes of this document, an instrument is
considered a subsystem (of the spacecraft).

Module: A major subdivision of the payload that
is viewed as a physical and functional entity
for the purposes of analysis, manufacturing,
testing, and record keeping. Examples include
spacecraft bus, science payload, and upper stage
vehicle.

Part: A hardware element that is not normally
subject to further subdivision or disassembly
without destruction of design use. Examples
include resistor, integrated circuit, relay,
connector, bolt, and gaskets.

Payload: An integrated assemblage of modules,
subsystems, etc., designed to perform a
specified mission in space. For the purposes of
this document, "payload" and "spacecraft" are
used interchangeably. Other terms used to
designate this level of assembly are Laboratory,
Observatory, and satellite.

Section: A structurally integrated set of
components and integrating hardware that form a
subdivision of a subsystem, module, etc. A
section forms a testable level of assembly, such
as components/units mounted into a structural

mounting tray or panel-like assembly, or components that are stacked.

Spacecraft: See Payload. Other terms used to designate this level of assembly are Laboratory, Observatory, and satellite.

Subassembly: A subdivision of an assembly. Examples are wire harness and loaded printed circuit boards.

Subsystem: A functional subdivision of a payload consisting of two or more components. Examples are structural, attitude control, electrical power, and communication subsystems. Also included as subsystems of the payload are the science instruments or experiments.

Unit: A functional subdivision of a subsystem, or instrument, and generally a self-contained combination of items performing a function necessary for the subsystem's operation. Examples are electronic box, transmitter, gyro package, actuator, motor, battery. For the purposes of this document, "component" and "unit" are used interchangeably.

Limit Level: The maximum expected flight.

Limited Life Items: Spaceflight hardware (1) that has an expected failure-free life that is less than the projected mission life, when considering cumulative ground operation, storage and on-orbit operation, (2) limited shelf life material used to fabricate flight hardware.

Margin: The amount by which hardware capability exceeds mission requirements

Module: See Level of Assembly.

Monitor: To keep track of the progress of a performance assurance activity; the individual performing the monitoring function need not be present at the scene during the entire course of the activity, but will review resulting data or other associated documentation (see Witness).

Nonconformance: A condition of any hardware, software, material, or service in which one or more characteristics do not conform to requirements. As applied in quality assurance, nonconformances fall into two categories--discrepancies and failures. A

discrepancy is a departure from specification that is detected during inspection or process control testing, etc., while the hardware or software is not functioning or operating. A failure is a departure from specification that is discovered in the functioning or operation of the hardware or software.

Outgassing: The emanation of volatile materials under vacuum conditions resulting in a mass loss and/or material condensation on nearby surfaces.

Part: See Level of Assembly.

Payload: See Level of Assembly.

Performance Verification: Determination by test, analysis, or a combination of the two that the payload element can operate as intended in a particular mission; this includes being satisfied that the design of the payload or element has been qualified and that the particular item has been accepted as true to the design and ready for flight operations.

Protoflight Testing: See Hardware.

Prototype Testing: See Hardware.

Qualification: See Design Qualification Tests.

Redundancy (of design): The use of more than one independent means of accomplishing a given function.

Repair: A corrective maintenance action performed as a result of a failure so as to restore an item to operation within specified limits.

Rework: Return for completion of operations (complete to drawing). The article is to be reprocessed to conform to the original specifications or drawings.

Section: See Level of Assembly.

Similarity, Verification by,: A procedure of comparing an item to a similar one that has been verified. Configuration, test data, application and environment should be evaluated. It should be determined that design-differences are insignificant, environmental stress will not be greater in the new application, and that manufacturer and manufacturing methods are the same.

Single Point Failure: A single element of hardware the failure of which would result in loss of mission objectives, hardware, or crew, as defined for the specific application or project for which a single point failure analysis is performed.

Spacecraft: See Level of Assembly.

Subassembly: See Level of Assembly.

Subsystem: See Level of Assembly.

Temperature Cycle: A transition from some initial temperature condition to temperature stabilization at one extreme and then to temperature stabilization at the opposite extreme and returning to the initial temperature condition.

Temperature Stabilization: The condition that exists when the rate of change of temperatures has decreased to the point where the test item may be expected to remain within the specified test tolerance for the necessary duration or where further change is considered acceptable.

Thermal Balance Test: A test conducted to verify the adequacy of the thermal model, the adequacy of the thermal design, and the capability of the thermal control system to maintain thermal conditions within established mission limits.

Thermal-Vacuum Test: A test conducted to demonstrate the capability of the test item to operate satisfactorily in vacuum at temperatures based on those expected for the mission. The test, including the gradient shifts induced by cycling between temperature extremes, can also uncover latent defects in design, parts, and workmanship.

Total Mass Loss (TML): Total mass of material outgassed from a specimen that is maintained at a specified constant temperature and operating pressure for a specified time.

Unit: See Level of Assembly.

Verification: See Performance Verification.

Vibroacoustics: An environment induced by high-intensity acoustic noise associated with various segments of the flight profile; it manifests itself throughout the payload in the form of directly

transmitted acoustic excitation and as structure-borne random vibration.

Workmanship Tests: Tests performed during the environmental verification program to verify adequate workmanship in the construction of a test item. It is often necessary to impose stresses beyond those predicted for the mission in order to uncover defects. Thus random vibration tests are conducted specifically to detect bad solder joints, loose or missing fasteners, improperly mounted parts, etc. Cycling between temperature extremes during thermal-vacuum testing and the presence of electromagnetic interference during EMC testing can also reveal the lack of proper construction and adequate workmanship.

Witness: A personal, on-the-scene observation of a performance assurance activity with the purpose of verifying compliance with project requirements (see Monitor).

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